STUDIES ON BOREAL AGROMYZIDAE (DIPTERA). VIII. *PHYTOMYZA* MINERS ON *ARTEMISIA* (COMPOSITAE)

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Eight species of the Phytomyza albiceps *group and one of the* Phytomyza robustella *group are recorded as leaf-miners of* Artemisia. *These include three new species from North America and one from Japan, as follows:* Phytomyza alaskana *n. sp. (type-locality Salcha River, Alaska),* P. hiemalis *n. sp. (type-locality Tokyo, Japan),* P. saxatilis *n. sp. (type-locality Kluane Lake, Yukon Territory) and* P. aurata *n. sp. (type-locality Kluane Lake, Yukon Territory). The life history of* Phytomyza demissa *Spencer is established for the first time.*

Huit espèces du groupe Phytomyza albiceps *et une du groupe* Phytomyza robustella *sont signalées comme mineuses dans les feuilles de l'*Artemisia. *Trois espèces nouvelles d'Amérique du nord et une du Japon sont inclues, tel que:* Phytomyza alaskana *n. sp. (localité-type Rivière de Salcha, Alaska),* P. hiemalis *n. sp. (localité-type Tokyo, Japon),* P. saxatilis *n. sp. (localité-type Lac Kluane, Territoire du Yukon) et* P. aurata *n. sp. (localité-type Lac Kluane, Territoire du Yukon). La biologie de* Phytomyza demissa *Spencer est determinée pour la première fois.*

Acht Arten der Phytomyza albiceps-*Gruppe und eine der* Phytomyza robustella-*Gruppe werden als Blattminierer von* Artemisia *besprochen. Unter diesen sind folgende drei nordamerikanischen Arten und eine japanische Art neu:* Phytomyza alaskana *n. sp. (Fundort des Typus: Salcha River, Alaska),* P. hiemalis *n. sp. (Fundort des Typus: Tokyo, Japan),* P. saxatilis *n. sp. (Fundort des Typus: Kluane Lake, Yukon Territorium) und* P. aurata *n. sp. (Fundort des Typus: Kluane Lake, Yukon Territorium). Die Lebensweise von* Phytomyza demissa *Spencer wird erstmals festgestellt.*

In this paper I continue the revision of *Phytomyza* miners on Compositae begun with my treatment of the miners of Senecioneae in Parts II and VI in this series (Griffiths, 1972b & 1974). *Artemisia* belongs to the Anthemideae, within which it supports a relatively discrete insect fauna (in other words, many *Artemisia*-feeding insects do not attack other Anthemideae). I have decided to restrict this paper to the miners of *Artemisia*, as I have not yet obtained adequate North American material from other groups of Anthemideae.

It is accepted that *Artemisia* was represented in the Arcto-Tertiary flora which formerly extended across North America and Eurasia (see, for instance, the works of D. I. Axelrod). As aridity and winter cold increased in the interior of the continents towards the end of the Tertiary, various *Artemisia* species became dominant elements in the flora of steppes and deserts with winter precipitation due to their ability to grow at low temperatures. The extent to which the history of *Artemisia*-feeding insects can be correlated with that of their host-plants has yet been scarcely investigated. In the case of the Agromyzidae, it appears that the most diverse *Artemisia*-feeding fauna in North America is found in boreal and subarctic areas, where I have collected species of *Calycomyza, Liriomyza* and *Phytomyza* (Fig. 35-36). So far I have found no trace of agromyzid feeding on *Artemisia* in the deserts and steppes of the western United States, although it is possible that these were visited at the wrong seasons. It is noteworthy that an exceptionally diverse agromyzid fauna occurs on *Artemisia* in the vicinity of the St. Elias icefields, around the South end of Kluane Lake. This area is well known for

the persistence of active loess deposition, as occurred widely around the great icefields during the Pleistocene glaciations. Here grow at least seven species of *Artemisia*, including one known nowhere else in North America. Such a high diversity of *Artemisia* species at a single locality is to the best of my knowledge unparalleled in North America. My samples of agromyzids from the Kluane area include two new species of *Phytomyza*, described below.

Further studies on the distribution of the agromyzid fauna of *Artemisia* in Beringia may help in understanding the significance of the high proportions of *Artemisia* pollen characteristic of certain periods during the Pleistocene. Problems of interpreting the kind of habitat indicated by the *Artemisia* peaks have arisen because palynologists cannot distinguish the pollen of different species of *Artemisia*. The pollen peaks have been variously interpreted as indicating wet tundra (*Artemisia arctica* Less.), loess fields (*A. frigida* Willd. and *A. rupestris* L.) or sand and gravel bars (*A. tilesii* Ledeb. and *A. alaskana* Rydb.). The available information, while admittedly still meagre, suggests that different species of the *Phytomyza albiceps* group are associated with different species of *Artemisia* in Beringia. If this is correct, then determination of the distribution of these flies, together with that of other host-specific phytophagous insects, on both the American and Asian sides of Beringia may indicate which species of *Artemisia* have had continuous distributions in this area during the Pleistocene. Such a survey of the distribution of *Artemisia*-feeding insects would be a major undertaking, but may be recommended as a test of the usefulness of the parasitological method in historical biogeography (that is, elucidation of the history of the hosts by analysis of the distribution of their parasites). This method seems potentially fruitful, but has so far been rarely applied in practice.

Comparison of the parasite fauna of a plant species in separate parts of its range to determine whether this was recently continuous is in principle analogous to comparing the fauna and flora of separate land bodies to determine whether they have been recently connected. In the case of recent fragmentation of a formerly continuous range, we may expect the plant's parasite fauna to be largely the same on either side of a gap in the range. In the case where a separated part of the range has resulted from long-distance dispersal across a gap, we may expect the plant to have a deficient parasite fauna in the relatively new part of the range. Very old fragmentation of a formerly continuous range may be indicated by vicariant parasite taxa on either side of a gap, and by failure of more recently acquired parasites to spread across a gap.

The holotypes of the new North American species described in this paper will be deposited in the Canadian National Collection (Ottawa); that of *Phytomyza hiemalis* belongs to K. A. Spencer. Names of North American species of *Artemisia* are used in the sense of Hultén (1968). Note that the plant called *Artemisia arctica* Less. by Hultén is considered a "variety" (subspecies in the sense of zoologists) of *A. norvegica* Fries by many authors; and that *A. furcata* Bieb. is often called *A. trifurcata* Steph. For Japanese plants I have followed as far as possible the nomenclature of Ohwi (1965), who recognizes as species various taxa traditionally listed by Japanese authors as "varieties" of *Artemisia vulgaris* L. However, I cannot determine to which species Kuroda's records of "*vulgaris*" without varietal names refer (the true *vulgaris* does not occur in Japan).

The terms and abbreviations used in my descriptions were explained in the first paper of this series (Griffiths, 1972a).

DIAGNOSIS

A key with worldwide coverage to the mines of *Phytomyza* and *Chromatomyia* species on *Artemisia* is given below.

Keys to North American species of the *Phytomyza albiceps* group and *P. robustella* group

have been given in Part VI (Griffiths, 1974). The following amendments incorporate the new species described in this paper.

Amendment to key to North American species of *Phytomyza albiceps* group

21. (19) Sides of thorax extensively yellowish white. Aedeagus as Fig. 4-5, with compact row of spinules on left side of basal section ..... *P. alaskana* n. sp.
– Thorax largely dark 21a
21a.(21) Acr in two rows. Costal ratio mg_2/mg_4 1.9-2.1. Aedeagus as Fig. 18-19 ..... *P. saxatilis* n. sp.
– Acr in 4-5 rows. Costal ratio mg_2/mg_4 at least 2.5 ..... 21b
21b.(21a) (as previous couplet 21)

Amendment to key to North American species of *Phytomyza robustella* group

9. (8) Distiphallus much expanded apically (Fig. 21-22). Frons yellow-brown to dark brown ..... *P. aurata* n. sp.
– Distiphallus less expanded apically 9a
9a. (9) (as previous couplet 9)

Key to *Phytomyza* and *Chromatomyia* mines on *Artemisia*

1. Puparium formed inside leaf, with anterior spiracles turned downwards, projecting ventrally through epidermis 2
– Puparium normally formed outside leaf; anterior spiracles not turned downwards ..... (*Phytomyza albiceps* group) 3
2. Faecal particles in mine widely spaced (Fig. 30). Puparia golden yellow. Alaska, Yukon and British Columbia ..... *Phytomyza aurata* n. sp.
– Faecal particles in mine not so widely spaced. Puparia white, brown or black ..... *Chromatomyia syngenesiae* group

The polyphagous *C. horticola* (Goureau) has been bred from *Artemisia* in Europe and Japan (Griffiths, 1967). Frick's (1952) North American record of "*Phytomyza atricornis* Meigen" presumably refers to *C. syngenesiae* Hardy.

3. Posterior spiracles of third instar larva and puparium with 11-16 bulbs. North America 4
– Posterior spiracles of third instar larva and puparium with at least 17 bulbs .. 6

The Japanese *Phytomyza tottoriensis* Kuroda will be taken to this couplet. I cannot place this species in the couplets which follow because of insufficient information.

4. Mine narrowly linear throughout (Fig. 31). On *A. arctica* Less. ..... *Phytomyza* sp. (compare *alaskana* n. sp.)
– Mine broader, with secondarily blotchy areas (Fig. 32-33) 5
5. On *A. arctica* Less. ..... *Phytomyza demissa* Spencer
– On *A. furcata* Bieb. and *A. alaskana* Rydb. ..... *Phytomyza saxatilis* n. sp.
6. Mine (Fig. 34) becoming more or less blotchy terminally. Posterior spiracles of third instar larva and puparium very large, with 31-44 bulbs (Fig. 27). Japan..... *Phytomyza japonica* Sasakawa ..... or *Phytomyza hiemalis* n. sp.
– Mine (Fig. 28-29) entirely linear, only 1-1.5 mm wide terminally. Posterior spiracles of third instar larva and puparium with 17-28 bulbs (Fig. 25) 7
7. Palaearctic Region ..... *Phytomyza artemisivora* Spencer ... or *Phytomyza matricariae* Hendel
– Alaska. On *A. tilesii* Ledeb. ..... *Phytomyza alaskana* n. sp.

TREATMENT OF SPECIES

(a) the *Phytomyza albiceps* group

Phytomyza artemisivora Spencer 1971

"*Phytomyza artemisiae* Kaltenbach". Linnaniemi, 1913: 84.
"*Phytomyza albiceps* Meigen". Hendel, 1923: 391. –1934: 337. De Meijere, 1926: 241. Hering, 1927: 119. –1930: 439. Sasakawa, 1953b: 116. –1961a: 438.
Phytomyza artemisivora Spencer. Spencer, 1971: 179. Holotype ♂, London (England), in K. A. Spencer's collection.

Adult. – Head (Fig. 24) with orbits only narrowly projecting above eye in lateral view; genae in middle 1/4 to 2/5 of eye height; eyes with only sparse fine pubescence. Frons at level of front ocellus 2-2½ times width of eye. Ors directed posteriorly, ori directed inwardly; only one strong ors present (posterior ors absent in most specimens, at most represented by short setula); anterior ori 1/3 to 1/2 as long as posterior ori; orbital setulae irregularly distributed in 1-2 rows. Peristomal margin with vibrissa and 3-7 upcurved peristomal setulae. Third antennal article rounded distally, with rather short pubescence.

Normally 3 + 1 dc (but 2 + 1 on one side and 1 + 1 on the other in one male); acr in 4-6 rows anteriorly; presutural ia numerous; 4-9 postsutural ia; inner pa 1/3 to 1/2 as long as outer pa.

Second cross-vein (m-m) absent. Costal ratio mg_2/mg_4 2.8-3.8 (means: ♂, 3.25; ♀, 3.35). Wing length: ♂, 2.0-2.35 mm (mean 2.2 mm); ♀, 2.3-2.55 mm (mean 2.4 mm).

Frons and orbits yellow, except dark ocellar plate and vertex (vte on dark ground; vti on boundary between dark and yellow ground). Face completely or largely yellow, at most weakly infuscated in antennal pits. Genae yellow. Occiput largely dark, but yellow at sides ventrally. Antennae with first article yellow to yellow-brown, second and third articles dark brown to black. Palpi black; labella yellow. Mesonotum dark centrally (weakly shining, finely grey-dusted), but with strongly contrasting broad yellowish-white side bands which enclose the humeral calli (indicated by brownish patch in centre) and extend posteriorly to the postalar calli (outer pa on boundary between yellowish and dark ground); small yellowish patches also before corners of scutellum (posterior to inner pa); scutellum dark; mesopleuron yellowish white on dorsal third to half, dark ventrally; other pleura largely dark, but with some whitish coloration along sutures. Wing base and squamae yellowish white, latter with dark fringe. Legs largely dark, with tips of femora contrastingly yellow; tibiae and tarsi largely brown to dark brown. Abdomen largely brown, but yellowish to varying extent along sides. Basal cone of ovipositor (♀) grey-dusted on about basal two-thirds.

Male postabdomen with 8th sternum fused with 6th tergum. Telomeres not clearly delimited from periandrium, bearing numerous fine setulae. Ventral extensions of pregonites inconspicuous, more or less membranous. Aedeagus as Fig. 1-2; basal sclerites narrow; extended row of 8-11 large spinules on left side on dorsal surface of basal section; sclerites of medial lobe fused distally, forming V; distal section with pair of spinules near base (these connected to apices of basal sclerites by weakly pigmented strips of sclerotization) and pair of curved tubules (distiphallus) arising from cylindrical area of sclerotization (pigmented dorsally only) about ejaculatory duct. Ejaculatory apodeme as Fig. 3.

The aedeagus has previously been figured by Sasakawa (1961a) and Spencer (1971).

Puparium and third instar larva. – Described by de Meijere (1926) and Sasakawa (1961a). Mandibles with two alternating teeth; right mandible longer than left. Anterior spiracles with two short horns, with 10-13 bulbs in widely open ellipse; posterior spiracles on short conical

projections, only slightly raised above level of last segment, with 17-22 bulbs in rather narrow, partly open ellipse (Fig. 25). Puparia dark brown to black, 1.8-2.1 mm long.

Sasakawa (1961a) gives the number of spiracular bulbs for Japanese material as 13-18 (anterior spiracles) and 19-28 (posterior spiracles).

Mine. – Larvae leaf-miners on *Artemisia* and, in Japan, on *Chrysanthemum*. Mine (Fig. 28) entirely linear, 8-11 cm long, 1-1.5 mm wide terminally; faeces deposited as fine particles along sides of mine, partly forming beaded strips; mine formed largely on upper surface of leaf (where appearing white or greenish white in reflected light when fresh), but with short initial channel (very inconspicuous) on lower surface; larvae leaving leaf through semicircular slit on upper surface before puparium formation.

Material examined. – 1 ♂ from larva 18.vii.54 on *Artemisia vulgaris* L., Slade Green, Kent, England, emerged 6.viii.54, leg. G. C. D. Griffiths. 3 ♂♂ 1 ♀ from larvae 24.vi.62 on *Artemisia vulgaris* L., Boxhill, Surrey, England, emerged 14.vii.62, leg. G. C. D. Griffiths; also preparation of larva from same sample. 6 ♂♂ 7 ♀♀ from larvae 6.viii.62 on *Artemisia vulgaris* L., Scratch Wood, Middlesex, England, emerged 24-28.viii.62, leg. G. C. D. Griffiths. 1 ♂ 1 ♀ from larvae on *Artemisia vulgaris* L., Bredow bei Nauen, Germany, emerged 15-20.iii.23, leg. M. Hering (no. 2162). 1 ♂ 1 ♀ from larvae on *Artemisia vulgaris* L., Berlin (-Frohnau), Germany, emerged 3.vii.28, leg. O. & M. Hering (no. 3299). 1 ♂ from larva on *Artemisia vulgaris* L., Krosno (Crossen an Oder), Poland, emerged 1.ii.30 (forced), leg. M. Hering (no. 5397).

Other records. – Spencer (1971) has listed as the types of *artemisivora* specimens bred from *Artemisia vulgaris* L. in England (Hampstead, London and Miller's Dale, Derby), Denmark (Horsholm) and Germany (Berlin). Von Tschirnhaus (in correspondence) has additional German material bred or swept from *Artemisia vulgaris* L. at localities near Kiel (Holstein), and also three males from puparia washed from bank debris of the Rhine at Cologne. Sasakawa's (1953b, 1961a) "*albiceps*" from Kyoto (Japan) seems to be conspecific, as evidenced by his figure of the aedeagus. In his first treatment Sasakawa (1953b) listed only *Artemisia* species as hosts, but gives a figure of a mined leaf which seems to belong to a *Chrysanthemum* species. In his 1961a treatment Sasakawa states that this species occasionally gives severe damage to cultivated chrysanthemum, an occurrence not reported in Europe where it seems confined to *Artemisia*. Sasakawa's (1961a) complete list of hosts, with nomenclature revised to accord with Ohwi's (1965) Flora of Japan, is as follows: *Artemisia absinthium* L., *A. indica* Willd., *A. montana* (Nakai) (= *vulgaris* L. var. *vulgatissima* Bess.), *A. keiskeana* Miq., *Chrysanthemum japonense* (Makino) (= *morifolium* Ram. var. *sinense* Makino) and *Rudbeckia laciniata* L. The last record is presumably to be deleted, as Sasakawa (1961b) subsequently lists only *japonica* from *Rudbeckia*.

There are many further records of "*albiceps*" on *Artemisia* in Europe. Probably most of these refer to *artemisivora*; but it is difficult to be confident in every case, as the mines of *artemisivora* could have been confused with those of *matricariae* (now confirmed on *Artemisia*, see below) and the adults have in the past been confused with those of several similar species. Nevertheless it may be useful for me to list here the sources of these unconfirmed records. All are of "*albiceps*" and based on mines on *Artemisia vulgaris* L., except where otherwise stated.

England – Manning (1956), Griffiths (1966: 808, 833, 871).

Holland – Amsterdam (de Meijere, 1962).

Germany – Buhr (1932, 1941a) (including also botanical gardens records for *Artemisia absinthium* L., *A. sacrorum* Ledeb., *A. annua* L., *A. atrata* Lam., *A. keiskeana* Miq., *A. moxa* DC. and *A. stelleriana* Bess.), Zoerner (1969).

Italy – Alto Adige (Hartig, 1939).

Poland – Karl (1936), Nowakowski (1954), Beiger (1956b, 1970, 1973), Griffiths (1966: 808, 871), Michalska (1970); also on *Artemisia absinthium* L. (Nowakowski, 1954; Beiger, 1965a).
Czechoslovakia – Starý (1930), Kvíčala (1938), Skala & Zavřel (1945), Zavřel (1956).
Jugoslavia – Hvar (Hering, 1967).
Roumania – Drăghia (1967).
Bulgaria – Buhr (1941b).
Denmark – Sønderup (1949).
Norway – Rydén (1955).
Sweden – Rydén (1937, 1948, 1952).
Finland – Linnaniemi (1913) (as "*artemisiae*", mostly on *Artemisia vulgaris* L. but also on *A. absinthium* L. in Helsinki Botanical Gardens), Frey (1937).
Russia – Karelia (Linnaniemi, 1913, as "*artemisiae*"), Moscow region (Rohdendorf, 1960).

Clearly, all records of caught specimens of "*albiceps*" should be set aside until the specimens have been dissected. This applies to some of Hendel's (1934) distribution records, although I have no doubt that his description is based primarily on *artemisivora*. Also all European records of "*albiceps*" on hosts other than *Artemisia*, such as de Meijere's (1926) for *Achillea* and *Pyrethrum*, should be assumed to refer to other species unless the contrary can be demonstrated.

Remarks. – In addition to the hosts listed above, Hendel (1934) reported this species (as "*albiceps*") also on *Artemisia campestris* L.

The name *albiceps* has had a chequered history, having been applied at one time or another to many different species. Hendel (1923) proposed to restrict it to the present species after examining Meigen's female type in the Winthem collection. Spencer however has reexamined this type, and concluded that Hendel's interpretation was incorrect. Spencer's name *artemisivora* should therefore be used as the first certainly available for this species. I understand that Spencer has a note in press on the identity of the true *albiceps*, which is not an *Artemisia*-feeder.

Kuroda's (1960a) description of the larvae of "*Phytomyza albiceps*" refers not to this species but probably to a *Liriomyza*.

There are no confirmed records of *artemisivora* in North America. Frick's (1959) statement that he had reared "*albiceps*" from leaves of *Artemisia vulgaris* L. in California refers to a single adult which can no longer be traced. I have seen Frick's pressed leaves (from the San Francisco Bay area) and identify them as the native *Artemisia douglasiana* Bess., not *A. vulgaris* L. The identity of the *Phytomyza* miner cannot be determined until bred males are obtained.

Phytomyza alaskana new species

Adult. – As described for *artemisivora*, except as follows.

Posterior ors absent in all specimens. 4-5 upcurved peristomal setulae. Acr in 4-5 rows anteriorly; 6-8 postsutural ia. Costal ratio mg_2/mg_4 3.2 in both specimens. Wing length 2.3 mm (♂), 2.55 mm (♀).

First antennal article yellow. Tibiae and tarsi largely yellow-brown to brown.

Aedeagus (Fig. 4-5) with more compact row of seven much shorter spinules on basal section; pair of spinules at base of distal section shorter; distiphallus appearing more or less straight in lateral view. Ejaculatory apodeme as Fig. 6.

Puparium and third instar larva. – Similar to those of *artemisivora*. Anterior spiracles with

about 12 bulbs; posterior spiracles with 18-22 bulbs. Puparia dark brown to black, 1.75-1.9 mm long.

Mine. – Larvae leaf-miners on *Artemisia tilesii* Ledeb., forming narrow linear mines (Fig. 29) as described for *artemisivora*; larvae leaving leaf through semicircular slit on upper surface before puparium formation.

Types. – Holotype ♂ from larva 12-14.vii.68 on *Artemisia tilesii* Ledeb. subsp. *elatior* (Torr. & Gray) on gravel bar at Salcha River crossing of Richardson Highway (64°29′N, 146°54′W), Alaska, emerged 18.ix.68, leg. G. C. D. Griffiths. 1 ♀ paratype from larva 2.viii.68 on *Artemisia tilesii* Ledeb. subsp. *elatior* (Torr. & Gray), Walker Fork (64°4′N, 141°38′W), Alaska, emerged 18.ix.68, leg. G. C. D. Griffiths.

Remarks. – This species is probably a geographical vicariant of its sister-species *artemisivora*, from which it differs most clearly in respect of the form of the aedeagus.

I have also bred a female from similar mines (Fig. 31) on *Artemisia arctica arctica* Less. collected 5-8.viii.70 at Summit Lake Pass (4200 feet elevation; Alaska Highway mile 392), British Columbia, emerged 10.v.71 (leg. G. C. D. Griffiths). This differs from the type material of *alaskana* in having a dark brown first antennal article, and the posterior spiracles of its puparium have only 12 bulbs. Probably it represents a new species, but I have decided to postpone formal naming until males have been obtained.

Phytomyza tottoriensis Kuroda 1960

Phytomyza artemisiae Kuroda. Kuroda, 1954: 78. Holotype ♀, Yokohama (Japan), lost.
Primary homonym of *Phytomyza artemisiae* Kaltenbach (1856).

Phytomyza tottoriensis Kuroda. Kuroda, 1960b: 266. New name for *Phytomyza artemisiae* Kuroda (1954).

Adult. – External form and colour as described by Kuroda (1954), similar to that of *artemisivora.*

Male postabdomen with 8th sternum fused with 6th tergum. Telomeres not clearly delimited from periandrium, bearing numerous fine setulae. Pregonites large, weakly pigmented, extending ventrally (shielding base of aedeagus at rest). Aedeagus as Fig. 7-8; basal section without spinules; sclerites of medial lobe contiguous at base with apices of basal sclerites, strongly sinuate, fused to form broad loop distally; distal section of similar structure to that of *artemisivora*, with pair of minute spinules near base (these connected to apices of basal sclerites by pigmented strips of sclerotization) and pair of curved tubules (distiphallus) arising from cylindrical area of sclerotization (largely pigmented) about ejaculatory duct. Ejaculatory apodeme large (Fig. 9).

Puparium and third instar larva. – Not described. The larva described as *albiceps* by Kuroda (1960a) and subsequently referred by him to *tottoriensis* (Kuroda, 1960b) is probably that of a *Liriomyza*, since the posterior spiracles have only three bulbs.

Mine. – Kuroda (1954) indicates only that the mine is linear ("serpentine") and that the larva leaves the leaf before puparium formation.

Material examined. – 1 ♂ 1 ♀ from larvae on *Artemisia* sp. (labelled *vulgaris*), Yazu-gun, Tottori prefecture, Japan, emerged 25.iv.57, leg. M. Kuroda (from K. A. Spencer's collection).

Remarks. – Additional material is needed to clarify whether this species can be reliably separated from *artemisivora* on external characters. Kuroda (1954) suggested slight differences in the wing venation and genae height, but I doubt whether these are clear-cut. I can make no progress with the available specimens, as their external condition is too poor.

The holotype female of this species was bred from *Artemisia japonica* Thunb. at Yokohama in November 1938. A series from *Artemisia "vulgaris"* were associated with this as paratypes.

This original material is now lost (Kuroda, in correspondence).

Kaltenbach (1856) described only the mine of his *Phytomyza Artemisiae*, the species now known as *Calycomyza artemisiae* (Kaltenbach). According to the 1961 International Code of Zoological Nomenclature, names based on the work of an animal are available if published before 1931. So Kaltenbach's early description of this species under *Phytomyza* (spelled *"Phythomyza"* through an obvious lapsus) preoccupies the name *Phytomyza artemisiae* Kuroda. Therefore the replacement name *tottoriensis* should be used.

Phytomyza matricariae Hendel 1920

This species will not be treated here in detail, as it is mainly a miner of other groups of Anthemideae. Spencer (1969) has figured the aedeagus. Sehgal (1971) conducted transfer experiments to determine the suitability of various plants for larval feeding by this species. An unidentified species of *Artemisia* was the only member of the Anthemideae to which he was not able to transfer the larvae successfuly, but he attributed this failure not to unsuitability of the plant but to difficulties in making the transfers caused by the very woolly surface of the leaf. He was able to demonstrate oviposition on *Artemisia* by females bred from *Tanacetum vulgare* L.

There are two European records of the occurrence of this species on *Artemisia* in nature, as follows. Hering (1963) bred a pair from larvae found 10.ix.62 on a plant of *Artemisia maritima* L. subsp. *salina* (Willd.) growing in H. Buhr's garden at Mühlhausen (Thuringia, Germany); Spencer (in correspondence) has dissected the male and agrees with this identification. Von Tschirnhaus (in correspondence) reports that he has received a male bred from *Artemisia absinthium* L., Freiburg/Breisgau (Germany), by P. Miotk in early August 1972. Whether the mines of this species on *Artemisia* can be distinguished from those of *artemisivora* remains to be clarified.

Phytomyza japonica Sasakawa 1953

Phytomyza japonica Sasakawa. Sasakawa, 1953a: 15. –1953b: 118. –1961a: 454. Kuroda, 1960a: 51. Holotype ♂, Saikyo (Japan), in Entomological Laboratory, Saikyo University.

Adult. – See the descriptions of Sasakawa (1953a, 1961a).

Male postabdomen with telomeres delimited from periandrum by distinct suture on outer side, bearing numerous fine setulae. Ventral extensions of pregonites inconspicuous, more or less membranous. Aedeagus as Fig. 10-11; spinules absent; basal sclerites fused basally, with their outer margins slightly dentate; sclerites of medial lobe fused distally, forming V; distal section with pair of transverse pigmented strips of sclerotization at base and pair of weakly pigmented divergent tubules (distiphallus) arising from unpigmented cylindrical area of sclerotization about ejaculatory duct. Ejaculatory apodeme (Fig. 12) rather small.

Puparium and third instar larva. – Sasakawa's (1953a, 1961a) and Kuroda's (1960a) descriptions and figures indicate a high number of spiracular bulbs (15-20 on anterior spiracles; 31-44 on posterior spiracles). Puparia blackish brown (Sasakawa, 1953a).

Mine. – Sasakawa's (1953a, 1953b, 1961a) description and figures indicate a gradually widening linear mine on upper surface of leaf, becoming more or less blotchy terminally, pale green in colour; faeces deposited as discrete particles; larvae leaving leaf before puparium formation.

Material examined. – 1 ♂ from larva on *Artemisia* sp. (labelled *vulgaris*), Yazu-gun, Tottori prefecture, Japan, emerged 25.iv.57, leg. M. Kuroda (from K. A. Spencer's collection).

Remarks. – The type series of this species was bred from *Kalimeris yomena* Kitam. (as

"*Aster indicus* L.") at Saikyo (Sasakawa, 1953a). Soon afterwards Sasakawa (1953b) listed two additional hosts: *Artemisia montana* (Nakai) (as *vulgaris* L. var. *vulgatissima* Bess.) and *Chrysanthemum japonense* (Makino) (as *morifolium* Ram. var. *sinense* Makino). These were not named as hosts in his 1961a treatment, but presumably through oversight as the records are repeated in his host-plant list (Sasakawa, 1961b). Further host-plants reported in one or both 1961 papers are: *Bellis perennis* L., *Rudbeckia laciniata* L. var. *hortensia* Bailey and *Hieracium japonicum* Fr. & Sav. This reported host range is surprisingly wide, and we are faced with the usual difficulty in evaluating Sasakawa's host-plant records that he does not state in all cases whether they are based on study of bred males. Nevertheless, the available male bred from *Artemisia* agrees well with his descriptions, which I assume to be based on the original material from *Kalimeris.* This seems to confirm that *japonica* is a species with an unusually wide host range.

Sasakawa (1953a) states that *japonica* has three to four generations a year, with larvae found in May, June, September and November. The reported localities are all in southern Japan, on Kyushu and southern parts of Honshu.

Phytomyza hiemalis new species

Adult. – Head with orbits only narrowly projecting above eye in lateral view; genae in middle 1/3 to 1/4 of eye height; eyes with only sparse fine pubescence. Frons at level of front ocellus about twice width of eye. Ors directed posteriorly, ori directed inwardly; posterior ors strong, half to almost as long as anterior ors; normally two ori, of which the anterior is variably developed, 1/3 to fully as long as the posterior (but in one female two additional ori differentiated on one side); orbital setulae numerous, mostly in 1-2 rows along eye margins but a few also near inner margins of orbits on anterior half of frons. Peristomal margin with vibrissa and 4-6 upcurved peristomal setulae. Third antennal article rounded distally, with short pubescence.

3 + 1 dc; acr numerous, in 4-6 rows anteriorly; presutural ia numerous; 9-12 postsutural ia; inner pa 1/3 to 1/2 as long as outer pa.

Second cross-vein (m-m) absent. Costal ratio mg_2/mg_4 2.8-2.9 in males (not measurable in female paratypes, as their wings are not fully expanded). Wing length: ♂, 2.4 mm (paratype) - 2.8 mm (holotype); ♀, about 3 mm.

Frons clear yellow centrally, with ocellar plate and vertex contrastingly black (vte on dark ground; vti on boundary between dark and yellow ground); orbits partly yellow, somewhat infuscated along eye margins and around bases of orbital setae. Face largely infuscated. Genae yellow. Occiput black. Antennae with first article dark brown, second and third articles black. Palpi black; labella yellow. Thorax almost entirely dark, strongly grey-dusted (scarcely shining), with contrasting whitish coloration only along seams of mesopleural and notopleural sutures; sides of mesonotum not contrastingly paler than centre, at most partly brownish; wing base and squamae whitish, latter with dark fringe. Legs largely dark, with tips of front femora contrastingly yellow; tips of other femora yellow to yellow-brown. Abdomen largely brown to dark brown. Basal cone of ovipositor (♀) grey-dusted on dorsal surface on basal third to half.

Male postabdomen with 8th sternum fused with 6th tergum. Telomeres not clearly delimited from periandrium, bearing numerous fine setulae. Pregonites large, weakly pigmented, extending ventrally (shielding base of aedeagus at rest). Aedeagus as Fig. 13-14; basal sclerites long, narrow and sinuate; row of about 20 short spinules on dorsal surface of basal half of basal section; sclerites of medial lobe fused distally, forming narrow slightly asymmetrical loop; distal section entirely unpigmented (transparent), with pair of divergent terminal tubules

arising from cylindrical area of sclerotization about ejaculatory duct. (Ejaculatory apodeme lost).

Puparium and third instar larva. – Mandibles with two alternating teeth; right mandible longer than left. Anterior spiracles knob-shaped, with about 20 bulbs in widely open ellipse; posterior spiracles very large, on short broad processes (not much raised above level of last segment), with 40-44 bulbs in branching stellate pattern (Fig. 27). Puparia reddish black, 2.2-2.5 mm long, with strongly prominent anal lobes.

Mine. – Larvae leaf-miners on *Artemisia keiskeana* Miq. Mine (Fig. 34) gradually widening linear-blotch, formed entirely on upper surface of leaf, appearing dull white or greenish brown in reflected light; faeces deposited as fine particles, mostly separated by less than 1 mm; larvae leaving leaf through semicircular slit on lower surface before puparium formation.

Types. – Holotype ♂, 1 ♂ 2 ♀♀ paratypes from larvae 20.i.60 on *Artemisia keiskeana* Miq., Tokyo Botanical Gardens, Japan, emerged late iii-17.iv.60, leg. K. A. Spencer.

Remarks. – I name this species *hiemalis* ("of winter") because the larvae were found feeding beneath snow in mid-winter. The large posterior spiracles with very numerous bulbs will enable its larvae and puparia to be distinguished from those of all other *Phytomyza* species on *Artemisia* except *japonica.*

The above description of the male aedeagus is based solely on the holotype. The paratype male has a defective, not properly differentiated aedeagus.

Phytomyza demissa Spencer 1969

Phytomyza demissa Spencer. Spencer, 1969: 239. Holotype ♂, Pete Lake (British Columbia), in Canadian National Collection, Ottawa.

Adult. – Head with orbits only narrowly projecting above eye in lateral view; genae in middle 2/5 to almost 1/2 of eye height; eyes with only sparse fine pubescence. Frons at level of front ocellus 2-2½ times width of eye. Ors directed posteriorly, ori directed inwardly; posterior ors strong, two-thirds to fully as long as anterior ors; two pairs of long ori and in most specimens shorter third pair; orbital setulae in 1-2 rows. Peristomal margin with vibrissa and 3-5 upcurved peristomal setulae. Third antennal article rounded distally, with short pubescence.

3 + 1 dc; acr irregularly distributed, in 2-4 rows; 5-10 presutural ia; 2-8 postsutural ia; inner pa normally 1/3 to 1/2 as long as outer pa (but absent on one side in one male).

Second cross-vein (m-m) absent. Costal ratio mg_2/mg_4 1.8-2.2. Wing length: ♂, 2.4-2.55 mm (2.8 mm in holotype according to Spencer, 1969); ♀, 2.55-2.7 mm.

Frons largely ochreous yellow to brown, becoming clear yellow to whitish posteriorly on either side of contrastingly black ocellar plate; vertex more or less dark as far as base of vti; orbits varying in colour, in some specimens largely ochreous yellow with infuscation only around bases of orbital setae, in others almost entirely infuscated. Face almost entirely infuscated (dark brown to black). Genae dull yellow to yellow-brown. Occiput black. Antennae with first article dark brown to black, second and third articles black. Palpi black; labella yellow to ochreous. Thorax almost entirely dark, strongly grey-dusted (scarcely shining), with traces of pale coloration only at outer corners of humeral calli and in seams of mesopleural and notopleural sutures; wing base and squamae dull whitish, latter with dark margin and fringe. Legs largely dark, with tips of front femora contrastingly yellow; tips of other femora less contrasting, yellow-brown or brown. Abdomen largely dark brown. Basal cone of ovipositor (♀) grey-dusted on basal third to half.

Male postabdomen with 8th sternum fused with 6th tergum. Telomeres delimited from periandrium by distinct suture on outer side, bearing numerous fine setulae. Ventral extensions of pregonites inconspicuous, more or less membranous. Aedeagus as Fig. 15-16; long row of

22-25 spinules on left side of basal section near dorsal margin of left basal sclerite; sclerites of medial lobe conspicuously angled near base, fused distally; narrow strip of weakly pigmented sclerotization on left side only at base of distal section; distiphallus consisting of pair of short, strongly divergent tubules arising from unpigmented cylindrical area of sclerotization about ejaculatory duct. Ejaculatory apodeme as Fig. 17.

Puparium and third instar larva. – Mandibles with two alternating teeth; right mandible longer than left. Anterior spiracles with two short horns, with about 12 irregularly distributed bulbs; posterior spiracles on short conical projections, only slightly raised above level of last segment, with 11-16 bulbs in partly open, broad (nearly circular) ellipse (Fig. 26). Puparia pale brown to dark brown, 2.0-2.4 mm long.

Mine. – Larvae leaf-miners on *Artemisia arctica* Less. Mine (Fig. 32) basically linear, but normally convolute (at least in part forming irregular secondary blotch), appearing pale green or greenish brown in reflected light when fresh; faeces irregularly distributed as fine particles throughout mine; most mines confined to upper surface of leaf, but a few partly on lower surface; larvae mostly leaving leaf through semicircular slit (on upper or lower surface) before puparium formation (but one female from Whistlers Mountain bred from puparium formed inside leaf).

Material examined. – 2 ♂♂ 2 ♀♀ from larvae and puparia 21.viii.71 on *Artemisia arctica arctica* Less., Whistlers Mountain (7500-7800 feet elevation), Jasper National Park, Alberta, emerged 11-12.v.72, leg. G. C. D. Griffiths. 1 ♂ 2 ♀♀ from larvae 25.viii.71 on *Artemisia arctica arctica* Less., on slopes above Mount Cavell Chalet (7400 feet elevation), Jasper National Park, Alberta, emerged 11.v.72, leg. G. C. D. Griffiths. 1 ♂ trapped on fellfield tundra at 8500 feet elevation in the Bald Hills (52°43′N, 117°41′W), Jasper National Park, Alberta, viii.71, leg. P. Kuchar.

Remarks. – The only specimen previously reported is Spencer's holotype caught at Pete Lake (57°56′N, 131°56′W; 4000 feet elevation), British Columbia, 19.viii.60.

This species is probably univoltine, and has been found only in highalpine areas, up to the limit of its host-plant's growth.

Phytomyza saxatilis new species

Adult. – Head with orbits scarcely projecting above eye in lateral view; genae in middle 1/4 to 2/5 of eye height; eyes with only sparse fine pubescence. Frons at level of front ocellus about twice width of eye. Ors directed posteriorly, ori directed inwardly; posterior ors about half as long as anterior ors, or absent (on one side in holotype); two strong ori (anterior ori half to almost as long as posterior ori); orbital setulae rather long, mostly clustered in area between posterior ori and anterior ors (not arranged in row along eye margin). Peristomal margin with vibrissa and 3-4 upcurved peristomal setulae. Third antennal article rounded distally, with rather short pubescence.

3 + 1 dc; acr in two rows; 3-4 presutural ia; 1-2 postsutural ia; inner pa about 1/3 as long as outer pa.

Second cross-vein (m-m) absent. Costal ratio mg_2/mg_4 1.9-2.1. Wing length 2.4 mm (both specimens).

Frons clear yellow centrally, with ocellar plate and vertex contrastingly black (vte on dark ground; vti on boundary between dark and yellow ground); orbits largely pale (whitish dusted over yellow ground-colour), but distinctly infuscated around bases of orbital setae and setulae. Face largely infuscated (more or less brown). Genae yellow. Occiput black. Antennae with first article brown, second and third articles black. Palpi black; labella yellow. Thorax almost entirely dark, strongly grey-dusted (scarcely shining); mesonotum with traces of pale coloration

only at corners of humeral calli; seams of notopleural and mesopleural sutures whitish; wing base and squamae yellowish white, latter with dark fringe. Legs largely dark, with tips of all femora contrastingly yellow. Abdomen largely dark brown. Basal cone of ovipositor (♀) grey-dusted on about basal two-thirds.

Male postabdomen with 8th sternum fused with 6th tergum. Telomeres delimited from periandrium by distinct suture on outer side, bearing numerous fine setulae. Ventral extensions of pregonites inconspicuous, more or less membranous. Aedeagus as Fig. 18-19; basal sclerites narrow; row of about 10 spinules along dorsal margin of left basal sclerite and group of three spinules on left side near apex of basal section; sclerites of medial lobe curved, contiguous (but not fused) distally; small spinule on left side only at base of distal section; distiphallus consisting of pair of more or less straight divergent tubules arising from unpigmented cylindrical area of sclerotization about ejaculatory duct. Ejaculatory apodeme rather large (Fig. 20).

Puparium and third instar larva. – Mandibles with two alternating teeth; right mandible longer than left. Anterior spiracles with two short horns, with 10 bulbs in widely open ellipse; posterior spiracles on short conical projections, only slightly raised above level of last segment, with 14-16 bulbs in broad (nearly circular) ellipse. Puparia brown, 2.1-2.2 mm long.

Mine. – Larvae leaf-miners on *Artemisia.* Mine (Fig. 33) on upper surface of leaf, probably basically linear with secondarily blotchy areas as in *demissa* (but shape in available samples partly determined by that of the narrow leaf-segments), appearing greenish brown in reflected light when fresh; faeces deposited as well separated particles; larvae leaving leaf through semi-circular slit on upper surface before puparium formation.

Types. – Holotype ♂ from larva 28.vii.72 on *Artemisia furcata* Bieb., near S end Kluane Lake (canyon of Williscroft Creek at 3000 feet elevation; 61°4′N, 138°32′W), Yukon Territory, emerged 17.v.73, leg. G. C. D. Griffiths. 1 ♀ paratype from larva 14.vii.72 on *Artemisia alaskana* Rydb., near S end Kluane Lake (storm beach at Horseshoe Bay campsite at 2550 feet elevation), Yukon Territory, emerged 15.v.73, leg. G. C. D. Griffiths.

Remarks. – This species seems to be univoltine. It is similar to *demissa* on external characters, but can be distinguished by its more brightly coloured head and less numerous mesonotal setulae. The name *saxatilis* ("frequenting rocks") refers to the habitat of the host-plants, which grow on cliffs, rock slides, storm beaches etc.

(b) the *Phytomyza robustella* group

Phytomyza aurata new species

Adult. – As described for *farfarae* (Part II: 391), except as follows.

2-4 upcurved peristomal setulae. Third antennal article with slightly longer pubescence. 4-8 presutural ia; 2-3 postsutural ia.

Costal ratio mg_2/mg_4 1.7-2.15 (means: ♂, 1.85; ♀, 1.9). Wing length: ♂, 2.35-2.6 mm (mean 2.5 mm); ♀, 2.6-2.8 mm (mean 2.7 mm).

Frons yellow-brown to dark brown centrally. Antennae entirely dark (first article not paler).

Male postabdomen and genitalia very similar to those of *farfarae* in most respects, but with clear differences in form of aedeagus (Fig. 21-22). Distiphallus more expanded apically; medial lobe with loop of unpigmented sclerotization around margin and membranous central spur. Ejaculatory apodeme as Fig. 23.

Puparium and third instar larva. – Similar to those of *farfarae.* Spiracles knob-shaped, anterior with 8-12 bulbs, posterior with 5-9 bulbs. Puparia golden yellow, 2.0-2.45 mm long.

Mine. – Larvae leaf-miners on *Artemisia.* Mine (Fig. 30) entirely linear, 9-12 cm long,

1-1½ mm wide terminally, on upper or lower surface of leaf, appearing greenish white in reflected light when fresh; faeces deposited as rather large particles, widely separated (by several mm) in terminal part of mine. Puparium formed on lower surface of leaf, with its ventral surface adjacent to surface of leaf, with its anterior spiracles projecting ventrally through epidermis.

Types. – Holotype ♂, 20 ♂♂ 19 ♀♀ paratypes from larvae and puparia 15-26.vii.72 on *Artemisia tilesii tilesii* Ledeb., near S end Kluane Lake (2800-4500 feet elevation; 61°N, 138°30′W), Yukon Territory, emerged 7-17.viii.72, leg. D. E. & G. C. D. Griffiths; 1 ♂ 2 ♀♀ paratypes from larvae and puparia 22.vii.72 on *Artemisia alaskana* Rydb., same locality (4000 feet elevation), emerged 7-13.viii.72, leg. G. C. D. Griffiths; 1 ♂ paratype from puparium 25.vii.72 on *Artemisia dracunculus* L., same locality (3000 feet elevation), emerged 10.viii.72, leg. G. C. D. Griffiths. 1 ♀ paratype from puparium 5-8.viii.70 on *Artemisia arctica arctica* Less., Summit Lake Pass (4200-4800 feet elevation; Alaska Highway mile 392), British Columbia, emerged 17.viii.70, leg. G. C. D. Griffiths.

Remarks. – The immature stages of this species were found in a variety of habitats near the South end of Kluane Lake, including dry slopes (on *Artemisia dracunculus* L.), canyons and gravel bars. They were especially abundant in a deep sheltered canyon on the North slope of Outpost Mountain. Two puparia were also found on *Artemisia furcata* Bieb., in addition to the hosts listed above from which adults were bred.

I also collected a mine with puparium, probably referable to this species, on *Artemisia arctica arctica* Less. at Eagle Summit (3900 feet elevation, Steese Highway, Alaska) on 17.vii.68.

The name *aurata* ("gilded") refers to the colour of the puparia. Most species of the *robustella* group have white puparia. The only other species of this group known to have yellow puparia is *P. hyperborea* Griffiths on *Petasites*, still known from only a single specimen (Griffiths, 1972). The adults of *aurata* are inseparable on external characters from those of several of the species described from Senecioneae in Parts II and VI (Griffiths, 1972b & 1974). The aedeagus must be studied carefully for reliable identification.

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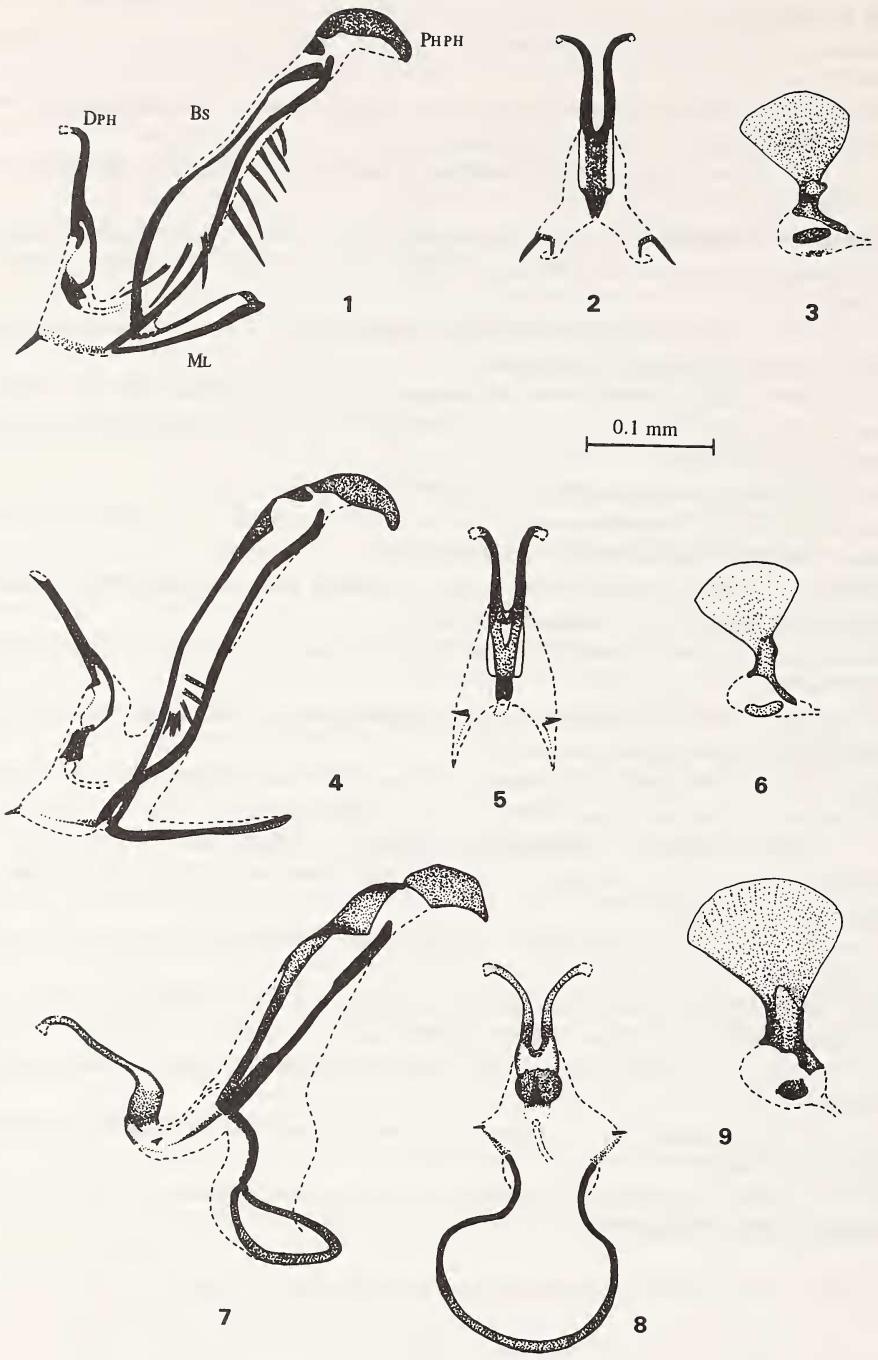

Fig. 1-3. *Phytomyza artemisivora* Spencer (♂), Boxhill, England: 1, aedeagus in left lateral view (BS basal section of aedeagus; DPH distiphallus; ML medial lobe; PHPH phallophore); 2, distal section of aedeagus in ± anterior view; 3, ejaculatory apodeme. Fig. 4-6. *Phytomyza alaskana* n. sp., holotype ♂: 4, aedeagus in left lateral view; 5, distal section of aedeagus in ± anteroventral view; 6, ejaculatory apodeme. Fig. 7-9. *Phytomyza tottoriensis* Kuroda (♂), Japan: 7, aedeagus in left lateral view; 8, distal section and medial lobe of aedeagus in ± anteroventral view; 9, ejaculatory apodeme.

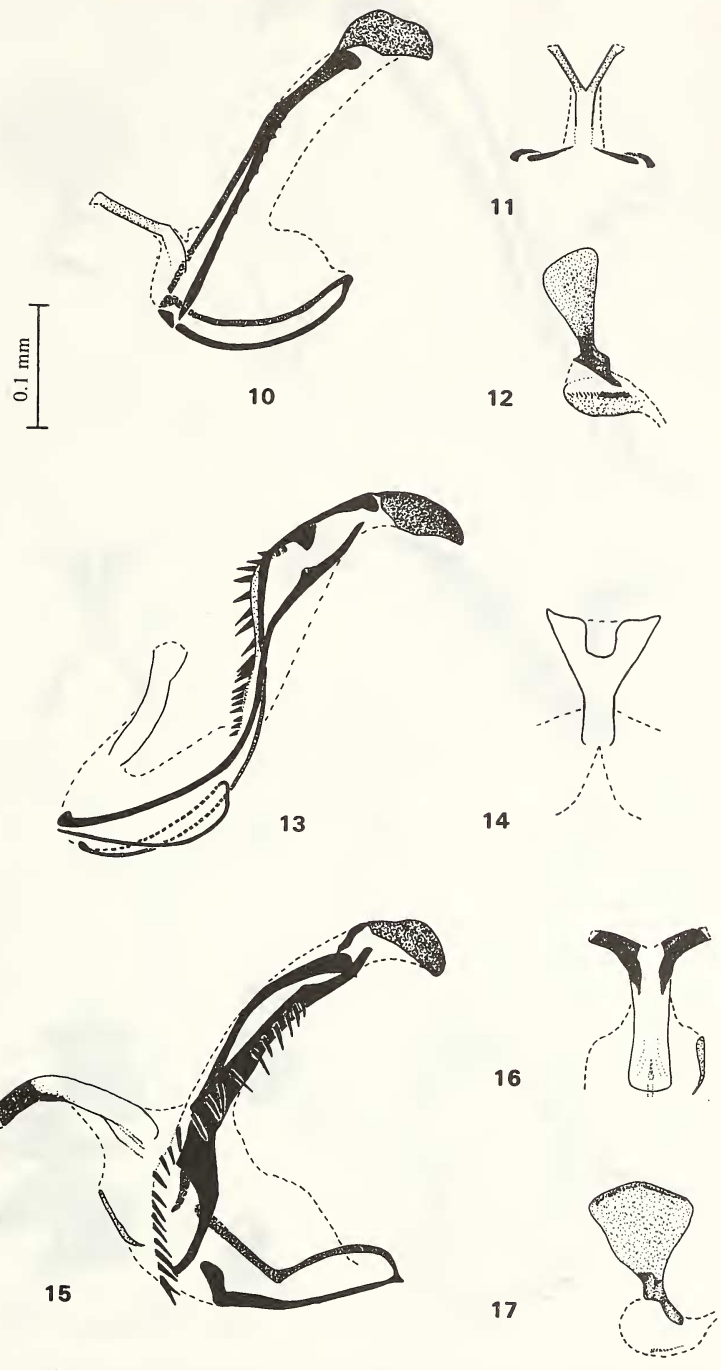

Fig. 10-12. *Phytomyza japonica* Sasakawa (♂), Japan: 10, aedeagus in left lateral view; 11, distal section of aedeagus in ± anteroventral view; 12, ejaculatory apodeme. Fig. 13-14. *Phytomyza hiemalis* n. sp., holotype ♂: 13, aedeagus in left lateral view; 14, distal section of aedeagus in ± anterior view. Fig. 15-17. *Phytomyza demissa* Spencer (♂), Alberta: 15, aedeagus in left lateral view; 16, distal section of aedeagus in ± anteroventral view; 17, ejaculatory apodeme.

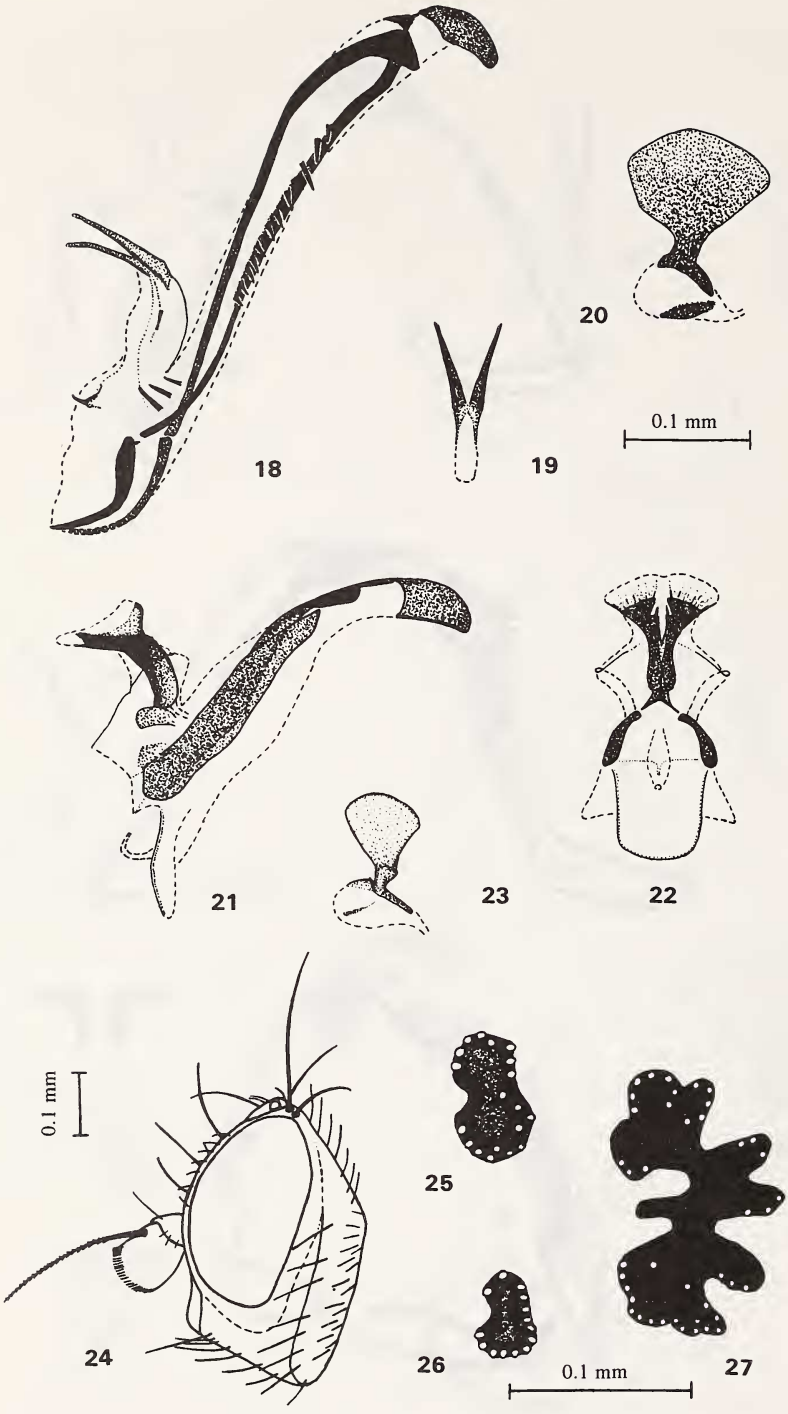

Fig. 18-20. *Phytomyza saxatilis* n. sp., holotype ♂: 18, aedeagus in left lateral view; 19, distiphallus in ± dorsal view; 20, ejaculatory apodeme. Fig. 21-23. *Phytomyza aurata* n. sp., holotype ♂: 21, aedeagus in left lateral view; 22, distal section and medial lobe of aedeagus in ± anteroventral view; 23, ejaculatory apodeme. Fig. 24-25. *Phytomyza artemisivora* Spencer, Boxhill, England: 24, head in left lateral view; 25, posterior spiracle of puparium in caudal view. Fig. 26. *Phytomyza demissa* Spencer (Alberta), posterior spiracle of puparium in caudal view. Fig. 27. *Phytomyza hiemalis* n. sp., posterior spiracle of puparium in caudal view.

Fig. 28. Leaf of *Artemisia vulgaris* L. with mine of *Phytomyza artemisivora* Spencer. Fig. 29. Leaf of *Artemisia tilesii* Ledeb. subsp. *elatior* (Torr. & Gray) with mine of *Phytomyza alaskana* n. sp. Fig. 30. Leaf of *Artemisia tilesii tilesii* Ledeb. with mine of *Phytomyza aurata* n. sp. Fig. 31-32. Leaves of *Artemisia arctica arctica* Less. with mines of: 31, *Phytomyza* sp. (compare *alaskana* n. sp.), Summit Lake Pass, British Columbia; 32, *Phytomyza demissa* Spencer. Fig. 33. Leaf of *Artemisia furcata* Bieb. with mine of *Phytomyza saxatilis* n. sp. Fig. 34. Leaf of *Artemisia keiskeana* Miq. with mine of *Phytomyza hiemalis* n. sp.

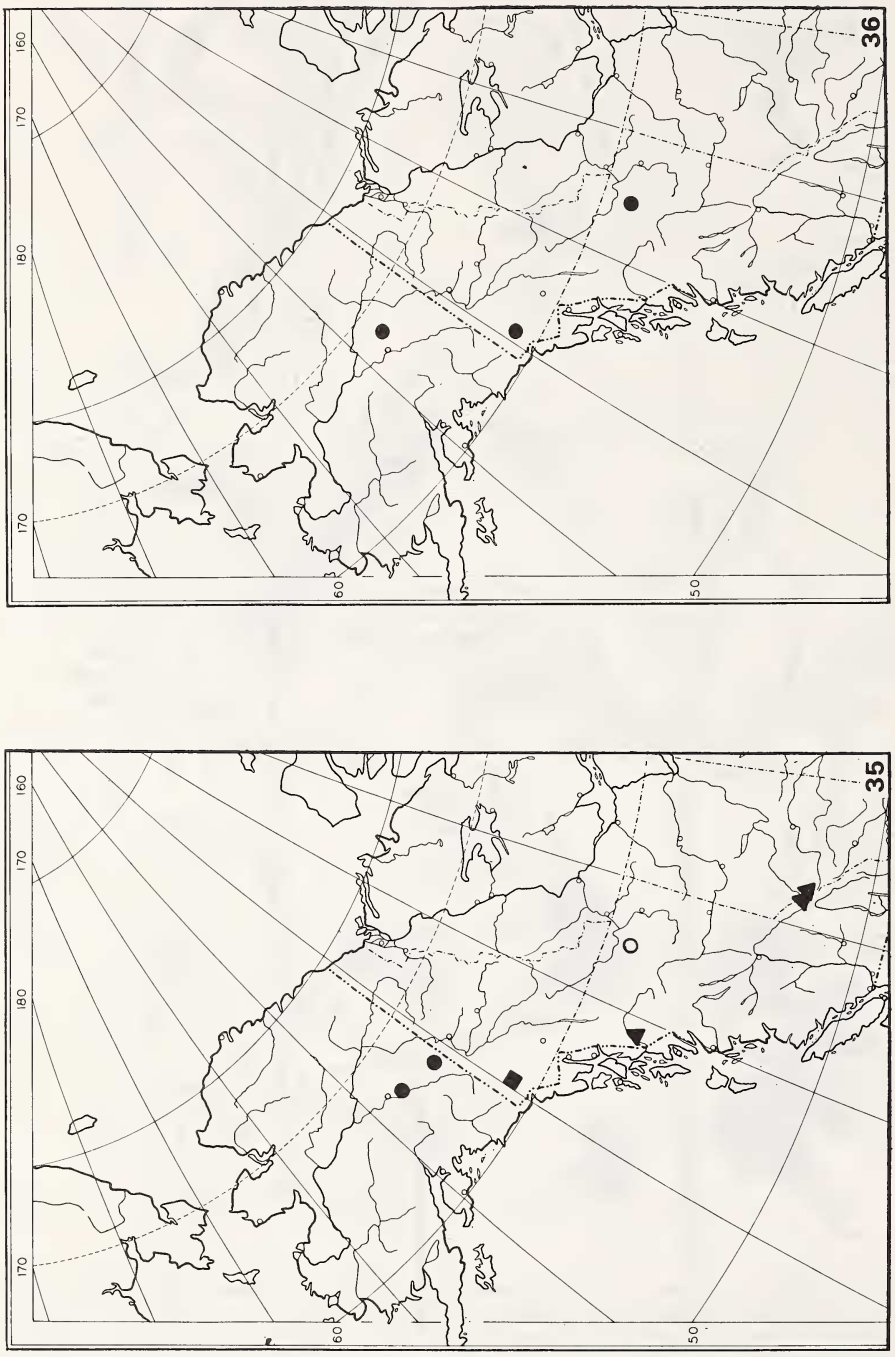

Fig. 35. Collection sites for *Artemisia*-feeding species of the *Phytomyza albiceps* group in North America (● *P. alaskana* n. sp.; ○ *P.* sp. [compare *alaskana* n. sp.]; ▲ *P. demissa* Spencer; ■ *P. saxatilis* n. sp.). Fig. 36. Collection sites for *Phytomyza aurata* n. sp.